Assessment of Temperature in Induction Heating by Inductive Sensor

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ABSTRACT:- In this paper we are introducing a new inductive sensor for temperature measurement in induction heating industries and simulation of a colpitts oscillator circuit that produces an inversly varying frequency output, according to the inductance value of the induction coil is done in LABview software. LABview is a software virtual instrumentation tool in which hardware configuration is possible. The oscillator circuit is coupled with the software by using Arduino kit. Different types of contact and non contact temperature sensors were analysed. We have done a comparison and analysis of contact temperature sensors like thermistor, RTD, thermocouple and the non contact sensor like infrared sensors. It was found that high frequency oscillators can be used to detect the frequency variations in the induction heating device. Colpitts oscillator was found more suitable for the detection of frequency variations, so we have selected the colpitts oscillator for this purpose. The colpitts oscillator have the frequency range of 20KHz to 300MHz.

Introduction

Temperature related process are inevitable to every industries. Almost all the industries uses various temperature related processes. And there will be a proper temperature measurement and temperature controls are needed for the working of industries. Many temperature sensors are used for the measuring purpose. We introduce a new inductive temperature sensors for the induction heating devices[1]. The temperature sensors are mainly classified into two different types such are contact sensors and non contact sensors. The sensors with are directly in contact with the object to be sensed is called contact sensors. Contact sensors use conduction to monitor the changes in temperature. These sensors can be used to measure the temperature of solids, liquids and gases in wide ranges. The sensors which uses convection and radiation to monitor the changes in temperature is called non contact sensors. These non contact sensors are used mainly to measure the temperature of liquids and gases. Both these contact and non contact sensors are classified in to three types such as electro-mechanical, resistive and electronics type. The contact sensors are RTDs, Thermocouple, thermisters etc and the non contact sensor is infrared temperature. Different industries use different types of heating methods. It may be furnace which works on furnace oil, fire wood, diesel, petrol or electricity ie, induction heating can be also used. The conventional temperature sensors have so many measuring losses in all this type of heating. The existing temperature sensors are not suitable for measuring temperature in induction heating devices. These sensors are not suitable for measuring the actual temperature since the coil in induction heating device is not actually heat up. These conventional temperature sensors are used to measure the temperature of the material to be heated. Newly introduced inductive temperature sensor can measure the variation in inductance and thereby calculate the temperature produced.

Currently used temperature sensors

Temperature sensors [2]:- The temperature sensors very in Operation from on and off thermostatic device which can control simple heating devices to semiconductor services which we can control largest furnace plants. Temperature sensors measure the heat or coldness offered by a system. Sense the physical changes to the temperature today using analogue or Digital output.

Contact temperature sensors :- The contact type temperature sensors are to be a physical contact with the heating system this type of sensors used the process of heating heat conduction to measure the changes in temperature. The contact sensors are thermistor, thermocouple, RTD.

Non contact temperature sensor :- The non contact temperature sensors uses the process of radiation and convection to measure the changes in temperature this type of sensors can be used to detect gases and liquid that events Radiant heat us heat Rises. Infrared radiations emitted from my heated object can be detected using the non contact temperature Celsius the example of contact lenses are thermostat thermistor Thermocouple RTD. On the example of non contact temperature sensor is Infrared temperature sensor.

Thermistor

When temperature increases resistance of thermistor decreases negative temperature Coefficient thermistors are commonly used as temperature sensors. It can measure temperature precisely within a limit range only. In induction cooktop thermistor present below the ceramic glass.

RTD

Resistance temperature dictator is also a contact temperature sensor. Of RTD is that the electrical resistance changes with the change in temperature. Fine gold wire wrapped around a ceramic or glass core. RTD element is mainly made up of Platinum.

Thermocouple

Thermocouple consists of two dissimilar conductor that contact each other at one or more spots. It produces a voltage when the temperature of one of the spots differs from the reference temperature at the other parts of the circuit. This principle is called seebeck effect. Some of the disadvantages of thermocouple is that it measures the radiated heat thus there are some measuring losses. It is not suitable for higher ranges of temperature measurement. The resistance temperature characteristics are non linear. It needs frequent re-calibration and and vulnerable to corrosion.

Themostat

A thermostat is a component which senses the temperature of a physical system and performs actions so that the system's temperature is maintained near a desired setpoint.

Thermostats are used in any device or system that heats or cools to a setpoint temperature, examples include building heating, central heating, air conditioners, HVAC systems, water heaters, as well as kitchen equipment including ovens and refrigerators and medical and scientific incubators. In scientific literature, these devices are often broadly classified as thermostatically controlled loads (TCLs).

Infrared temperature sensor

Infrared temperature sensor and infrared energy been focus hit by a lens on to a surface to detect the surface temperature[3]. The reflected beam is received back in the sensor which convert the energy to electrical signal that can be displayed in the units of temperature. In induction cooktops IR sensors are used over the ceramic glass to measure the temperature of the Wall of the cooking vessel but in frying process it is necessary to measure the temperature of the base of the pot so this sensor has to be placed below the surface of the glass.

Proposed sensor

In our project we are using a high frequency colpitts oscillator circuit for the detection of frequency changes. There is an inductive coil in the induction heating device, we are controlling the temperature of the induction heating device by varying the input power of the device or by varying the current passing through it, then the inductance of the inductive coil changes. the inductor which is used in the colpitts oscillator circuit is magnetically linked with the inductive coil of the induction heating device any changes in the inductance of the inductive coil imparts a corresponding change in the inductance of the inductor in the colpitts oscillator we can see this change as the frequency changes in the output waveform of the colpitts oscillator this frequency variations are calibrated In variations of temperature by using LabVIEW software. The colpitts oscillator is placed near the inductive coil of the induction heating device and the output of the colpitts oscillator is interfaced with the computer by using arduino kit and the output waveform is fed into the labVIEW software. By using some simulation blocks and scaling methods we are calibrating this frequency variations into corresponding temperature variations.

Fig1: block diagram

Need of high frequency oscillator

High frequency oscillators have a frequency range in 20hz to 300Mhz. Here we require to using oscillator of frequency 600Khz to 1Mhz . Because frequency is inversely proportional to inductance. So according to the value of inductance, there is a high frequency output to oscillator. Here we concluded that a high frequency oscillator is require for detecting the values. The different types of high frequency oscillators crystal oscillator, hartley oscillator and colpitts oscillator.

Crystal Oscillator

A crystal oscillator is an electronic oscillator circuit which is used for the mechanical resonance of a vibrating crystal of piezoelectric material. It will create an electrical signal with a given frequency. This frequency is commonly used to keep track of time for example: wrist watches are used in digital integrated circuits to provide a stable clock signal and also used to stabilize frequencies for radio transmitters and receivers. Crystal oscillator circuit usually works on the principle of the inverse piezoelectric effect. The applied electric field will produce a mechanical deformation across some materials. Thus, it utilizes the vibrating crystal's mechanical resonance, that is made with a piezoelectric material for generating an electrical signal of a particular frequency.Micro controllers we are using an 8MHz crystal oscillator.

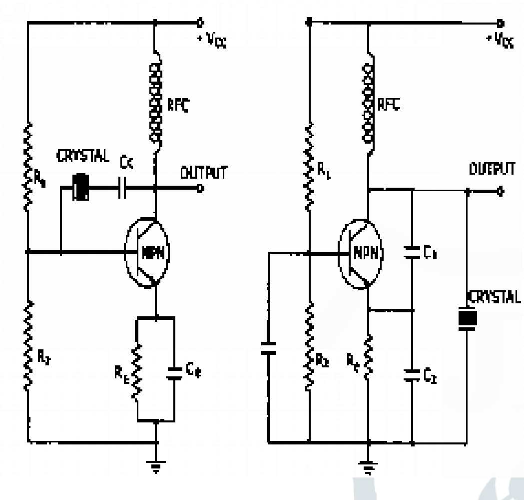

Fig 2: Crystal oscillator

Hartley oscillator

Hartley oscillator is inductively coupled, variable frequency oscillators where the oscillator may be a series or shunt fed. Hartley oscillators is the advantage of having one tuning capacitor and one center tapped inductor. This processor simplifies the construction of a Hartley oscillator circuit. The circuit diagram of a Hartley oscillator is shown in the below figure. An NPN transistor connected in a common emitter configuration works as the active device in amplifier stage. R1 and R2 are biasing resistors and RFC is the radio frequency choke, which provides the isolation between AC and DC operations.

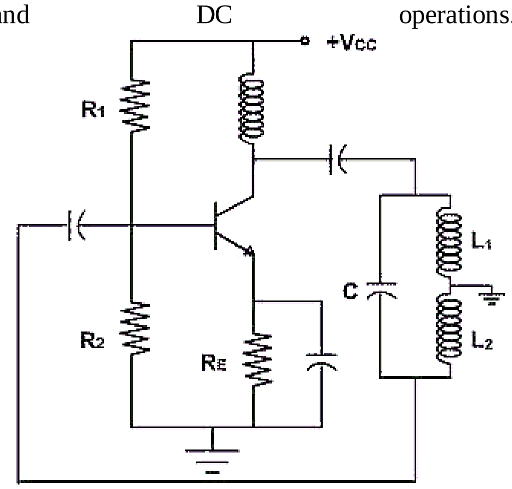

Fig 3: Hartley oscillator

Colpitts oscillator

Colpitts oscillator is an amplifier with the positive feedback and it converts DC input signal into AC output waveform with certain variable frequency drive and certain shape of output waveform by using the positive feedback instead of input signal. Oscillators which utilizes the inductor L and capacitor C in their circuit are called as LC oscillator which is a type of linear oscillator. . It consists of a tank circuit which is an LC resonance sub circuit made of two series. Capacitors connected in parallel to an inductor and frequency of oscillations can be determined by using the values of these capacitors and inductor of the tank circuit. This oscillator is almost similar to Hartley oscillator in all aspects; hence, it is termed as electrical dual of Hartley oscillator and is designed for the generation of high frequency sinusoidal oscillations with the radio frequencies typically ranging from 10 KHz to 300MHz. The major difference between these two oscillators is that it uses tapped capacitance, whereas the Hartley oscillator uses tapped inductance.

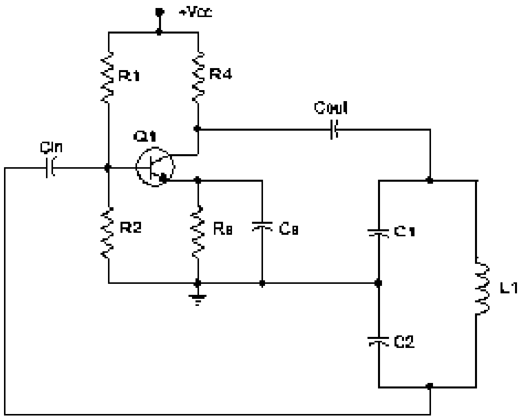

Fig 4: Colpitts oscillator

Need of colpitts oscillator and its design

The requirement of our project is clear that we need a oscillator that have a frquency range of 600Khz to 1 Mhz and variation of frequency should be done by varying the inductance. And the colpitts oscillator satisfies requirement.

$$f = \frac{1}{2\pi\sqrt{LC}}$$

This is the output frequency equation of colpitts oscillator. Where

F= frequency output

L= equivalent inductance

C = equivalent capacitance

L and C are designed so as to obtain the maximu frequency of 1 Mhz.

Temperature measurement method

In a induction heating device the temperature is produced based on the eddy current effect. The heating device consist of a coil wound in a core. When a AC supply is given to the coil a alternating magnetic field is produced. This magnetic flux is linked with a ferromagnetic material causes the generation of eddy current[4]. Eddy current is the free circulating current that rotates in a opposite direction of emf. Here in the vessel or material that is subjected to heating doesn't have a winding the eddy current is not taken out and it is circulated at the bottom of the vessel. And by the resistance of the vessel it get heated up. The temperature of a induction heating device is varied by changing the current through the coil. The change in current through the coil result in temperature by changing the effective inductance of coil. These change in inductance is coupled to the coil of oscillator by mutual induction. And there by the change in frequency is calibrated to temperature by using the software LABView. Some calibrated values are give below.

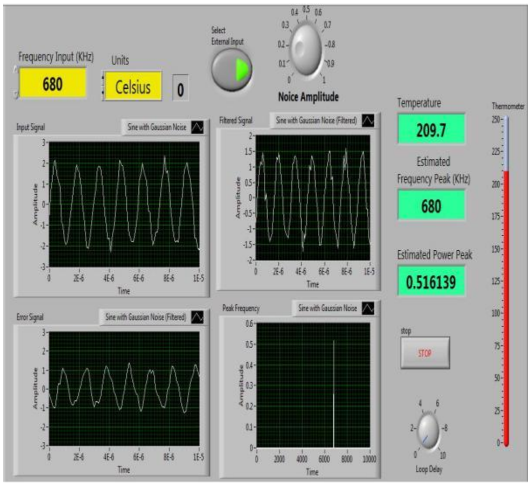

Fig5: temperature at 680 Khz.

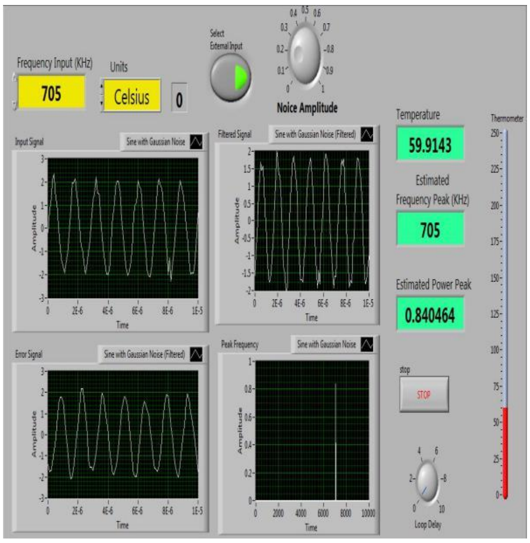

Fig 6: temperature at 705 Khz.

Conclusion

The type of temperature measurement is accurate so the it measures the heat produced by a induction heating device by determining the actual inductance.

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